Clean: To what extent do US consumers clean their refrigerators?

Conclusion
Moderate, consistent evidence shows that US consumers do not clean their refrigerators following available guidance.

Grade: Moderate
Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades, click here

Evidence Summary Overview

A total of four cross-sectional studies were reviewed on the extent to which US consumers clean their refrigerators. Children. The four studies received Ø quality ratings.

Four cross-sectional studies all reported cleanliness and sanitation of refrigerators as a problem. Bryd-Bredbenner et al, (2007) found that young adults scored less than 60% on the appliance cleanliness and cold food storage scales. Kosa et al, (2007) found that among a large adult sample, 53% of participants had not cleaned their refrigerator for at least one month before the survey. Kilonzo-Nthenge et al, (2008) identified 19 different bacterial isolates including *Listeria innocua* in 4.4% of domestic refrigerators in a study in Tennessee. They also identified *Klebsiella pneumoniae* and *Enterobacter cloacae* in 23.4% and 20.5% of the refrigerators, respectively, and identified multi-drug antibiotic resistance in *Klebsiella* and *Enterobacter spp*. Although most of the bacteria identified are non-pathogenic to healthy adults, they do serve as sanitation markers. Thus, findings indicate that proper food and refrigerator sanitation practices were not being followed in a significant proportion of households. Godwin et al, (2006) found in Florida and Tennessee households that 72% of swabs contained viable microbial populations, as assessed by way of adenosine triphosphate bioluminescence. The highest microbial loads were detected in the vegetable compartment and the meat sections. The microbial load in the vegetable compartment correlated significantly with the cleanliness score for that compartment. Only 5% of the respondents reported emptying and cleaning the entire refrigerator often or very often, with 78% reporting doing so occasionally or rarely. Godwin et al, (2006) documented that consumers' self-reports of vegetable compartment cleaning frequency did not correlate with microbial loads found in domestic refrigerators. Thus, proper refrigerator hygiene techniques may not be followed even when the behavior is practiced.

Evidence Summary Paragraphs

Byrd-Bredbenner et al, 2007, in a neutral-quality cross-sectional survey, audited the home kitchens of 154 young adults at a northeastern university to identify food safety problems. Home kitchen audits assessed kitchen cleanliness, appliance cleanliness, cleaning supplies availability, temperatures (thermometer access and refrigerator/freezer temperatures), cold food storage, dry food storage and poisons storage. Participants scored 70% or higher on kitchen cleanliness, and cleaning supplies availability, with females scoring higher than males on kitchen cleanliness (P=0.0183) and cleaning supplies availability (P=0.0305). Participants scored lower than 60% on the appliance cleanliness.

Godwin SL et al, 2006 in a neutral quality cross-sectional study, correlated visual perceptions of cleanliness by trained observers and self-reported refrigerator cleaning practices with microbial contamination measures in home refrigerators. Self-reported data was collected form 147 consumers in Florida or Tennessee regarding their food handling and refrigeration knowledge and practices, the contents and cleanliness of their refrigerators was assessed by trained observers and the microbial contamination on internal surfaces of their refrigerators was measured using microbial ATP (mATP) bioluminescence assay. Using the assay test, 72% of swabs had detectable mATP indicating majority of home refrigerators had viable microbial populations and the highest mATP were found in vegetable bins (but 14% had undetectable levels) and meat areas. Microbial ATP in vegetable bins was correlated with the cleanliness score for that compartment; cleanliness scores for several compartments were correlated with mATP found on the bottom shelf; a majority of participants reported often or occasionally cleaning compartments within their refrigerators, but half rarely or never emptied and cleaned the refrigerator; mean mATP was greater in refrigerators that were emptied and cleaned less frequently; and mATP in refrigerator compartments failed to show a clear relationship to reported refrigerator cleaning frequency. Authors concluded that visual appraisal is not a reliable method of assessing microbial

contamination in a home refrigerator, nor are self-reported cleaning practices of consumers reliable in predicting microbial contamination.

Kilonzo-Nthenge A et al, 2008 in a neutral quality descriptive study, determined the prevalence and identity of microorganisms in domestic refrigerators. Samples from various interior locations (shelves, meat and vegetable drawers or middle drawer) in home refrigerators in 137 homes in middle Tennessee were taken, inoculated into different media, and tested using standard procedures to determine occurrence of *Listeria spp*. and *Enterobacteriaceae* in those refrigerators. Listeria monocytogenes was not isolated in any of the refrigerators, but these bacteria were isolated: *Listeria innocua* (4.4%), *Enterobacter sakazakii* (2.2%) and *Yersinia enterocolitica* (0.7%), *K. pneumoniae* (23.4%), *Klebsiella oxytoca* (6.8%), *Klebsiella terrigena* (4.0%), *Enterobacter cloacae* (20.5%) and *Pantoea spp*. (13.9%). For *Enterobacteriaceae* and aerobic colony counts, the highest mean log CFU per sample count was in vegetable bins, followed by bottom shelves, middle shelves, meat drawers and top shelves. Mean *Enterobacteriaceae* count recovered from vegetable bins was significantly higher ($P<0.05$) than mean counts in recovered from meat drawers and top shelves, and similarly, mean aerobic colony count log CFU per sample recovered from the vegetable bins was significantly higher ($P<0.05$) than the mean count recovered from the bottom, middle, top shelves and meat drawers. Authors note that findings indicate the need for greater consumer education regarding proper domestic refrigerator cleaning and safe food handling practices in domestic kitchens.

Kosa et al, 2007, in a neutral-quality cross-sectional study, surveyed a nationally representative sample of 2,060 adults in the US (249 pregnant women, 946 older adults and 865 from the remaining population) to collect data on refrigerator thermometer ownership, home refrigerator temperatures and the frequency of cleaning for home refrigerators. The demographic characteristics of consumers following government-recommended refrigerator practices were also assessed, in terms of gender, age, educational background, marital status, household size, race or ethnicity, household income, metropolitan status and whether or not a member of the household had been diagnosed with diabetes, kidney disease or another condition that weakens the immune system. About half (47.4%) of all respondents had cleaned their refrigerators at least one month prior to the survey.

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Author, Year, Study Design, Class, Rating	Population/Sample Description and Location	Study Design/I & D Variables/Intervention	Results/Behavioral Outcomes/Significance	Limitations
Byrd-Bredbenner et al, 2007 Study Design: Cross-sectional study Class: D Rating:	154 young adults at a northeastern university. Location: United States.	Home kitchen audits assessed kitchen cleanliness, appliance cleanliness, cleaning supplies availability, temperatures (thermometer access and refrigerator/freezer temperatures), cold food storage, dry food storage and poisons storage.	Participants scored ≥70% on poisons storage, dry food storage, kitchen cleanliness and cleaning supplies availability, with females scoring higher than males on kitchen cleanliness ($P=0.0183$) and cleaning supplies availability ($P=0.0305$). Participants scores <60% on the appliance cleanliness and cold food storage scales. Performance was lowest on the temperatures scale; only 7% of kitchens had a food	Temperature measurements not available for all participants due to thermocouple malfunction. Home kitchen audits limited to participants at one university.

			thermometer.	
Godwin SL, Fur-Chi C et al, 2006 Study Design: Cross-sectional study Class: D Rating: 	147 subjects (84% female, 16% male). 53% White, non-Hispanic, 31% African American, 14% Hispanic. 92% had high school diplomas or degrees; 84% had household income of >$15,000. 12% of households consisted of ≥five persons. 147 household refrigerators (minimum of two surfaces swabbed in each refrigerator; total number of samples=369).	**Design:** Participants completed a home refrigeration practices survey. Conditions of participants' refrigerators were evaluated by a trained observer. Cleanliness, fullness and organization of five areas (door; upper, middle and bottom shelves and vegetable bins) of each refrigerator were recorded on a four-point scale and potentially unsafe circumstances noted. Several 100cm^2 areas of each refrigerator (usually meat area (either a compartment or location where meat was stored), bottom shelf and vegetable bin) were swabbed with sterile buffer. A microbial ATP (mATP) bioluminescence assay was performed on the swabs to assess microbial contamination. **Dependent variables**: Microbial ATP levels (measured via bioluminescnence assay). Independent Variables: Self-reported refrigerator practices including handling of cold foods and cleaning frequency; Recorded condition of consumer's refrigerator with respect to cleanliness, fullness and organization (based on scoring by trained observer using a checklist) and recorded potentially unsafe or	72% of swabs had detectable mATP indicating majority of home refrigerators had viable microbial populations; highest mATP were found in vegetable bins (but 14% had undetectable levels) and meat areas. mATP in vegetable bin was correlated with the cleanliness score for that compartment. Cleanliness scores for several compartments were correlated with mATP found on the bottom shelf. mATP in refrigerator compartments failed to show a clear relationship to reported refrigerator cleaning frequency. Refrigerators of those who reported more often cleaning spills in their refrigerators had greater mATP values on the bottom shelves ($r=0.251$, $P<0.05$). A majority of participants reported often or occasionally cleaning compartments within their refrigerators, but half rarely or never emptied and cleaned the refrigerator. Mean mATP was greater in refrigerators that were emptied and cleaned less frequently.	Subjectivity of trained observers' cleanliness scores. *The authors noted these limitations:* ATP bioluminescence results may be altered by the presence of cleaning agents and chemical sanitizers or disinfectants (and about two-thirds of subjects in this study reported using some type of cleaning compound either often or occasionally within their refrigerators). Speculation that some participants may have cleaned their refrigerators before the researchers arrived, even though they had been asked not to do so (this cleaning was apparent to the researchers in a few instances).

		unusual conditions within the refrigerator.		
Kilonzo-Nthenge et al, 2008 Study Design: Descriptive study Class: C Rating: 	N=137 household refrigerators in middle Tennessee (three samples from each refrigerator). N=411 total number of samples. Location: United States.	**Design:** To determine the prevalence and identity of microorganisms in domestic refrigerators, swab samples were taken from various interior locations (shelves, meat and vegetable drawers or middle drawer) in home refrigerators. Swabs were inoculated into different media and standard procedures were used to test the isolates for *Listeria spp.* and *Enterobacteriaceae.* **Dependent variables:** Isolation of: • *Listeria spp.* • Aerobic plate counts • *Enterobacteriaceae* counts.	*Listeria monocytogenes* was not isolated in any of the refrigerators, but these bacteria were isolated: • *Listeria innocua* (4.4%) • *Enterobacter sakazakii* (2.2%) • *Yersinia enterocolitica* (0.7%) • *K. pneumoniae* (23.4%) • *Klebsiella oxytoca* (6.8%) • *Klebsiella terrigena* (4.0%) • *Enterobacter cloacae* (20.5%) • *Pantoea spp.* (13.9%). For *Enterobacteriaceae* and aerobic colony counts, the highest mean log CFU per sample count was in vegetable bins, followed by bottom shelves, middle shelves, meat drawers and top shelves. Mean *Enterobacteriaceae* count recovered from vegetable bins was significantly higher ($P<0.05$) than mean counts in recovered from meat drawers and top shelves and similarly, mean aerobic colony count log CFU per sample recovered from the vegetable bins was significantly higher ($P<0.05$) than the mean count	No information on demographics of households with refrigerators. No funding source information.

			recovered from the bottom, middle, top shelves and meat drawers. Authors note that findings indicate the need for greater consumer education regarding proper domestic refrigerator cleaning and safe food handling practices in domestic kitchens.	
Kosa et al, 2007 Study Design: Cross-sectional study Class: D Rating:	Nationally representative sample of 2,060 adults in the United States (249 pregnant women, 946 older adults and 865 from the remaining population).	Data collected on refrigerator thermometer ownership, home refrigerator temperatures and the frequency of cleaning for home refrigerators. The demographic characteristics of consumers following government-recommended refrigerator practices were also assessed, in terms of gender, age, educational background, marital status, household size, race or ethnicity, household income, metropolitan status, and whether or not a member of the household had been diagnosed with diabetes, kidney disease or another condition that weakens the immune system.	About half (47.4%) of all respondents had cleaned their refrigerators at least one month prior to the survey. Only 10.7% of all respondents had a thermometer in their refrigerator prior to the survey. After receiving the refrigerator thermometer as part of the survey, 72% of all respondents reported that they refrigerators were at the recommended temperature.	Not all respondents completed all questionnaire information. Relatively small sample size of pregnant women. Self-reported practice may not reflect actual practice.

Research Design and Implementation Rating Summary
For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70 (4): 991-996.

Godwin SL, Fur-Chi C, Coppings RJ. Correlation of visual perceptions of cleanliness and reported cleaning practices with measures of microbial contamination in home refrigerators. *Food Protection Trends*. 2006; 26 (7):

474-480.

Kilonzo-Nthenge A, Chen FC, Godwin SL. Occurrence of *Listeria* and *Enterobacteriaceae* in domestic refrigerators. *J Food Prot.* 2008; 71: 608-612.

Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70 (7): 1,640-1,649.